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Struggling with inertia: Regime barriers opposing planning and implementation of urban ropeways

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ABSTRACT

Urban ropeways are a novel option to extend public transport. Technically suited to a range of use cases, urban ropeways have not yet been implemented as part of a public transport solution in Germany. Rather than the technology itself, specific routines and practices of the public transport service regime have been identified as main challenges. Building on series of expert workshops conducted in 2017 (23 participants in total), we look beyond technical characteristics and study the preparedness of service regime actors regarding processes and routines as well as structural factors of inertia. Generally, we observe an increasing openness towards reflecting about integrating urban ropeways into public transport. However, misalignment is still clearly visible: First, lacking experiences with this new option at the local level imply a time-consuming need for information and clarification. Second, and more fundamentally, the suitability of established planning routines is questioned, which is critical because the dense regulatory framework existing in Germany currently requires these. We discuss the implications at the level of the service regime and the relevance of these structural mechanisms in considering technological potentials in a mobility transition more generally.

1. Introduction

During the last decade, ropeway[1] technology has increasingly been suggested as one suitable option to extend urban public transport networks (Alshalalfah et al., 2014; Clément-Werny & Schneider, 2012; Monheim et al., 2010), and a number of already existing installations worldwide demonstrate the capabilities of the technology. Some inherent characteristics make urban ropeways a promising option in public transport: they can help overcome topographical or other physical barriers with a system that is associated with fewer financial resources compared to conventional public transport technologies under similar condition (e.g. tunnels or bridges needed), and they promise faster implementation.

Ropeway technology comprises different options ranging from aerial tramway systems with only one or two bigger cabins using a fixed timetable (transport capacity depending on route length and the resulting minimum trip intervals) to detachable gondola systems with varying cabin capacities and cabin headways using continuous operation (maximum transport capacity: up to 6000 people per hour and direction) (Alshalalfah et al., 2014; Alshalalfah et al., 2012). Transport capacities can therefore be adjusted to the requirements of a specific route and are in the range of bus services or simple tram systems, but below light rail or rapid transit systems. Generally, ropeways use established technology which is extensively used in mountainous regions and at skiing destinations in particular, predominantly implying a touristic focus that comes with its own actor constellations and routines. However, there are still ongoing technological developments, particularly considering improvements for urban applications. For example, Težak et al. (2016) suggest new station layouts to further increase transport capacities, and a number of approaches consider combining conventional route sections (using carrying ropes) with complementing technologies, particularly rail-bound sections (Kairos gGmbH, 2016) or autonomous shuttle carriers (RWTH Aachen, 2020).

Urban ropeways are no silver bullet for urban transport problems or a substitute for established public transport technology. Rather, urban ropeways draw their potential from a range of situations where conventional modes regularly reach their limits (Monheim et al., 2010; Reichenbach & Puhe, 2018). Typical situations include overcoming physical barriers (hills, rivers, motorways, etc.), connecting major points of interest as well as peripheral sites to public transport nodes, relieving overcrowded routes in existing public transport, closing gaps in existing networks, or a combination of these.

Despite the technological potentials, however, even in potentially suitable situations urban ropeways are not yet routinely considered as an option in public transport planning, particularly not in Europe and,

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[1] Alternative terms with varying usage include ‘cable cars’, ‘aerial tramways’ or ‘gondolas’, partly referring to specific sub-types of the technology. Funicular railways are a related technology, but are not discussed in this article.

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more specifically, in Germany. Urban ropeway projects have been or are still discussed in a growing number of German cities, but until now, none of these projects has been actually implemented as a fully integrated public transport service (Reichenbach & Puhe, 2018). The few ropeway installations that actually operate in German cities have a clearly identifiable touristic focus (e.g. Koblenz, Berlin), a few more recent projects come with a clear public transport focus but are still at the planning stage (e.g. Bonn, Stuttgart, Munich).

As documented in a recent review by Tiessler et al. (2020), the scientific literature on urban ropeways is also still rather limited. For example, uncertainties and open questions relate to the fields of construction and operation costs (Težak et al., 2016), legal assessments and planning procedures (Stennecken & Neumann, 2016), or the integration of urban ropeways into transport demand modelling (Hofer et al., 2016; Reichenbach et al., 2017). Considerations revolving around technological aspects of urban ropeway technology must, however, be complemented by further analyses to actually deliver an understanding of the technology's innovation process as a whole. In this paper we seek to contribute to a more detailed understanding of whether and how relevant local actors responsible for the planning process struggle with the new options offered by urban ropeway technology. We address professional actors' perceptions and expectations with regard to urban ropeways as well as concrete factors of inertia in the service regime.

The relevance of this perspective lies not only in understanding the prospects for urban ropeways as an interest in itself, but also in illustrating typical challenges of the sector in dealing with innovative public transport solutions in a broader sense. Considering the rising public debate around a mobility transition (driven by considering both the transport sector's carbon footprint and local burdens of dense individual motor traffic) it is of crucial importance to understand the ability of public transport to handle the aspired network and service extensions. Trying to do so, the complex interplay of actors and routines in the mobility system calls for an integrated perspective that considers the interplay between technologies, industries, policies, user preferences, social norms, etc. (Geels, 2012). In a similar line, Docherty et al. (2018) call for special attention to the 'how' of managing the transition and to broaden perspectives beyond policy objectives and technological solutions. While technologies from sharing services to vehicle automation attract huge public attention, most experts agree that conventional public transport will remain an important backbone and should receive appropriate attention (cf. e.g. International Transport Forum, 2015 , 2017) – with urban ropeways being one potential piece of the puzzle.

The consideration of complex institutional contexts is the reason for focusing on a single country. We are aware that, from a technology perspective, the most prominent international examples of urban ropeway applications relate to Southern America. The institutional setting though is not readily comparable to the German context with its specific combination of regulatory framework conditions, urban planning routines, existing public transport networks, actor constellations, etc.

1.1. Research goal: understanding regime barriers for urban ropeways

In this article, we address both professional actors' general views on urban ropeways and stabilizing factors embedded in current regime practices. We conduct our analysis along the following guiding questions:

- How do professional actors from the public transport service regime at the local level perceive potentials for the application of urban ropeways as a new transport option?
- Which elements of misalignment can be observed between the requirements of potential urban ropeway projects and established planning routines in the service regime?

The first question addresses professional actors' perceptions of the general proposition of urban ropeways to potentially contribute to public transport service extensions. If professional actors agree with this proposition, it is then of crucial importance to understand any structural barriers to the actual implementation of urban ropeways. The combination of these perspectives builds the ground for a discussion of misalignment challenges in the ongoing diffusion process of urban ropeways. The relation between existing misalignment, stabilizing factors, and how the involved actors deal with it (as part of a potential realignment process) is of particular interest for assessing whether the technology may actually play a future role in a more sustainable mobility system.

1.2. Innovation processes in the public transport service regime

In order to understand misalignment (and realignment processes) and stabilizing factors in the provision of public transport, we use the multi-level perspective as a heuristic background, focussing on the level of the socio-technical regime. Geels (2012, p. 473) refers to socio-technical regimes as sets of deeply rooted rules and routines that coordinate technologies, companies, institutions, policies, users, etc. Established institutional logics and routine choices help reproducing and stabilizing regimes, with a rather incremental potential for innovations (Fünfschilling & Truffer, 2014; Geels, 2012). Yet, with regard to the transport system, there is no single transport regime, as for example different transport modes each have their established actor networks etc.; Geels (2012) refers to automobility as the dominant regime, complemented by a number of subaltern regimes, including public transport. Van Welie et al. (2018) consider the heterogeneity of (sectoral) regimes by introducing the concept of "service regimes" which exist in parallel, characterized by "specific institutionalized combinations of technologies, user routines, and organizational forms for providing the service" (p. 260). This concept has also been applied to the transport sector, considering different transport service regimes (Schippl & Truffer, 2020). One important element in the analysis of service regimes refers to (mis-)alignment and realignment processes, considering the interplay between its different elements (including infrastructures and technologies, organisational configurations and institutions, shared understandings, user practices and needs, or business models). For example, Schippl and Truffer (2020) refer to current misalignments between established diesel technology and rising health concerns, or increasing cycling shares confronted with infrastructure deficits. Alignment is a key element both regarding the internal organisation of service regimes and regarding the fit with external developments (at the sectoral regime and landscape levels) and ongoing innovation processes (Schippl & Truffer, 2018; Van Welie et al., 2018).

Regarding the German public transport service regime in particular, Monheim and Schroll (2004) as well as Karl (2014) analysed structural mechanisms that support stability and hamper innovation take-up within the service regime, particularly relating to planning routines and existing regulatory frameworks. Scherf (2018) analysed interactions between actors from the established public transport service regime and mobility providers from other service regimes. Looking at integrated mobility cards, he presented the challenges of bringing together their different practices from still separated social worlds, and how these limit the aspired effects of integrated mobility cards.

Similarly, specific challenges at the service regime level have been identified for urban ropeways. While ropeway technology is well-established in specific service regimes outside public transport (e.g. winter tourism, see above), urban ropeways require new actors from the public transport service regime to engage with that technology. In an earlier study, we identified a number of factors specifically at the regime level affecting this process (Reichenbach & Puhe, 2018): On the one hand, established planning routines and actor constellations based on extensive experiences with established means of public transport complicate the take-up of urban ropeways, which do not fit into these routines without friction. On the other hand, actors from the public transport service regime generally experience a pressure to become more innovative, often triggered by actors from outside the service regime and considering the wider discussions about a mobility transition. This

also leads service regime actors themselves to discover urban ropeways as an interesting option. Drivers and barriers do also exist at the level of the technological niche (e.g. restricted route layout or interference with urban landscapes as inherent factors limiting the urban ropeway niche, or misalignment of project ideas with public transport needs) and the socio-technical landscape (e.g. search for local flagship projects as a driver, general public opposition against major infrastructure projects as a barrier). However, the interplay of the various factors at the level of the public transport service regime seems most relevant for the discussion of the ongoing diffusion process.

While the study by Reichenbach and Puhe (2018) was based on an explorative series of expert interviews on the specifics of ropeway projects in general, the added value of the present article is the systematic approach of discussing opportunities, barriers and needs with local experts in a pre-defined setting (see Section 2). This allows for a more detailed understanding of the factors sketched out above. It is also noteworthy that most recently – and after the empirical part of the present study had been conducted – a number of concrete steps towards including urban ropeways into established planning tools and procedures can be observed particularly at the federal level in Germany. We include these developments in our discussion, relating them to our direct observations.

1.3. Typical steps in extending public transport networks in German cities

For understanding our subsequent analysis of how the public transport service regime deals with urban ropeways, it is important to take a very brief look at how service regime actors in Germany 'normally' approach service extensions and new public transport network elements.

Local transport policy is closely interrelated with aspects of urban development, environmental impacts, social cohesion, etc. in local policies (Gertz et al., 2018, p. 312). In an integrated planning approach, many local authorities therefore use transport development plans. Mostly, these plans are commissioned and then prepared by external consultants in order to later build the basis for a local authority's policy measures and transport investments within a certain timeframe (Gertz et al., 2018, p. 313). Closely related to that wider framework, public transport plans are legally required, commissioned and regularly renewed by those authorities (mostly cities and counties) that are defined as responsible for organising public transport (Dziekan & Zistel, 2018; Holz-Rau et al., 2009), sometimes supported by separate public transport development plans. In these plans, weaknesses and general investment needs in the existing public transport network are identified. One important element of the different plans is ensuring that public transport delivers the desired public value defined by its function as a public service. Besides, this consideration also motivates the complex regulatory framework regarding approval and licensing procedures as well as public tendering, subsidies and service contracts in operating local public transport (Dziekan & Zistel, 2018).

Typically, when it comes to concrete infrastructure extensions and public investment – and often interlaced with the political decision-making process around the above-mentioned general plans – technical feasibility studies are done (or commissioned), followed by defining available and required financial resources and preparing for detailed engineering (Stiewe, 2006). At this stage, also other public actors beyond public transport planners are involved in order to check their interests in a project and optimize plans. One important requirement – particularly regarding the application for investment subsidies – is to prove the public value of a project, usually by means of a cost-benefit analysis. Specifically in Germany, a standardized appraisal method prescribes in detail which forms of costs and benefits need to be taken into account, and the calculation rules (e.g. factor weights) (Köhler, 2014, p. 141). Since investment subsidies depend on a positive evaluation, this standardized approach has a crucial relevance for the feasibility of a public transport project. Lastly before the actual implementation of a project, and depending on the type of the planned infrastructure, the detailed engineering phase may legally require specific procedures, including public involvement, until construction is actually permitted.

2. Case description and methods

Considering the general challenges for urban ropeways identified at the level of the public transport service regime, we present a case study that seeks to allow a more detailed understanding of these factors, particularly addressing the roles of involved actors. We conducted research to analyse expectations towards the new means of transport and identify challenges in the hypothetical planning process of potential urban ropeway lines in three cities in the federal state of Baden-Württemberg, Germany. The purpose of looking at concrete cities was to go one step further from a general discussion of potentials and barriers of urban ropeways or the analysis of previous plans bound to the specific contexts and factors beyond the public transport service regime in their respective cities. Instead, we used a consistent approach across the three cities to analyse potentials and restrictions, considering typical actor settings with regards to planning processes for new infrastructures in the context of the public transport service regime at the local level. At that level, consequences of the new option become more tangible and insights can be linked to the actual scope of action of the respective regime actors. Our study follows a qualitative research approach, using expert workshops to understand different regime actors' views, patterns of argumentations and lines of thought (Alvesson & Sköldberg, 2018).

2.1. City selection

For the study, we selected three different cities in Baden-Württemberg along several criteria: The analysis was restricted to this federal state in order to ensure sufficiently consistent framework conditions across all selected cities, particularly regarding actor constellations, transport planning routines, and the legal framework. In a first screening, we looked for cities where we could identify one or more of the typical situations challenging conventional public transport (see introduction) as relevant issues for local public transport planning.

We considered cities that were already engaged in actual discussions about extending their local public transport system (whether by an urban ropeway or by other means of transport), which we took as a proxy for the existence of potentially suitable challenges in the respective city's transport system. The final selection included Stuttgart, Konstanz and Heidelberg. The three cities come with different urban structures, different urban transport challenges, and different population characteristics, hence providing a combined and rich picture of potential urban ropeway use cases that allows a broad analysis of issues and arguments in experts' reasoning about urban ropeways.

Stuttgart (2016: 626,000 inhabitants) has got an extensive light rail system, next to regional and commuter rail. All of these are running at the limits of current capacity and service extensions are no longer easily possible. Congestion is still a huge challenge due to difficult topography in the city centre. Increasing public transport modal shares ranges high on the political agenda. A potential urban ropeway corridor had already been included as an option in the city's strategic local public transport plan (Verkehrs- und Tarifverbund Stuttgart GmbH [VVS], 2017). During the project, a second corridor started to be publicly discussed (Hintermayr, 2017).

Konstanz (2016: 83,000 inhabitants) is characterised by its location at the Rhine River, separating the often congested city centre from the almost complete rest of the city, including the university campus, with very limited bridges available. Except the railway line, the city only has a bus network. An upgrade of the city's public transport system was already debated when the project started, including tramway and urban ropeway options (Stadt Konstanz, 2017).

Heidelberg (2016: 158,000 inhabitants) has a tramway system, regional and commuter trains. The Neckar River separates its city centre and the railway station from its main university campus, including a

hospital and other research facilities, with the university being the city's largest employer. A new tram line had long been planned for this area, but has been overruled by court (Stadt Heidelberg, 2016), with alternatives being publicly discussed during the project (Buchwald, 2017).

2.2. Expert workshops

In each of the three selected cities, an expert workshop was conducted in order to explore the local potential of urban ropeways and expectations of the experts regarding hypothetical planning steps for an urban ropeway. The relevant experts invited to the workshops were selected purposefully, respecting the particularities of the three cities. They included representatives from administration (incl. transport planning, urban planning, monument conservation, and finance departments), local public transport operators and local public transport associations, as well as NGOs engaged in fostering public transport. The actual workshops were held in July 2017, with seven to eight participating experts (23 participants in total) and three members of the project team for moderation and documentation. The workshops started with a brief introduction regarding technical characteristics of urban ropeways by a member of the project team. A semi-structured approach was then chosen, starting with the identification of potential ropeway corridors in the respective city's public transport system by the group. Further questions addressed potential effects on the residents' mobility behaviour, more general effects in the respective city, as well as potential planning challenges and conditions for a successful urban ropeway project. That way the experts' perspectives, closely linked to their locally established working routines, served to distil a coherent problem structuring of potential urban ropeways, respecting the variety of the respective contexts.

2.3. Analytical approach

Each workshop was digitally recorded and transcribed. The structure laid out by the guiding questions (see above) served as a first starting point for the qualitative analysis. Categories were then iteratively enriched and restructured while working through the transcripts and interpreting the course of the discussions (cf. Silverman, 2020), using MAXQDA 2018 data analysis software to support the analytical process. Arguments were systematically collected in order to understand the participants' reasoning about urban ropeways in their cities and more generally. We paid particular attention to any aspects of existing service regime misalignment or ongoing and completed realignment processes as perceived by the participating experts. We looked at whether statements related to the respective local situation and the roles of specific actors or whether general developments and framework conditions at the level of the public transport service regime were addressed. Moreover, a distinction could be made between the general perception of ropeway technology and its suitability for urban transport purposes vs. considerations regarding the concrete steps and issues in planning and implementing potential urban ropeway projects, helping to understand the relevance of the identified issues. In the results section, translated quotes from the workshop discussions serve to illustrate the identified key arguments around which the discussions evolved.

3. Results

In the following sections, potential urban ropeway use cases in the three case study cities, challenges of integrating those into public transport, potential impacts on urban development as well as expectations regarding hypothetical planning steps are presented.

3.1. Use cases for urban ropeways

In all of the three workshops, participants were generally rather open towards introducing urban ropeways as an alternative means of transport. This was despite the fact that some of them had initially perceived the urban ropeways as a weird idea, a technology that had its place in the mountains and at tourist attractions. Yet, particularly when hearing about or dealing with the first urban ropeway ideas in the three cities, the experts had come to view urban ropeways as an option that at least deserves a detailed analysis of its potentials. This was despite the many challenges, for example regarding restricted route layout and integration into urban landscapes, that were seen as obstacles and that were also discussed in detail later during the workshops. In a number of statements, this general openness was related to a wider discussion that public transport needs to be aware of ongoing innovations and also societal developments that lead to a pressure on the sector to leave beaten tracks and provide new answers to increasing challenges.

A major advantage of urban ropeways was seen in overcoming problems with limited street space at ground level, in particular where current bus lines reach their capacity limits, where bus intervals can no more be increased or buses get stuck in traffic. In line with existing literature on urban ropeways (see above), a number of typical potential use cases were discussed by the workshop participants (Table 1). Along with this, a number of potential urban ropeway corridors was identified in each of the three cities (Fig. 1), which then served as the basis for the subsequent detailed discussions.

3.2. Integration into public transport networks

In all three cities it was clear for experts that, in order to become efficient as a part of the respective public transport system, integration crucially requires thinking about the physical points of interchange as well as about tariff integration. Besides being a requirement when applying for financial support according to federal state rules (which at the same time rules out leaving the pricing completely in the hands of a private operator), this means ensuring that the introduction of the additional means of transport does not build new barriers for passengers, which was identified as one important factor for user acceptance:

> *Full integration into the public transport system [...] in all regards, both operational and regarding tariffs, is absolutely essential.*
> – regional public transport association representative –

The necessary interchanges between an urban ropeway line and other means of public transport were seen as a challenge, since interchanging was generally supposed to be a factor reducing user acceptance. However, participants argued that an interchange including an urban ropeway with its small cabins at high frequency (at least for those ropeway subtypes perceived most suitable for urban applications) is something different and might actually not be perceived as problematic by passengers. Still, interchanging was supposed to remain a challenge when scheduling transfers between the continuous passenger flow of a ropeway line and the typically discontinuous timetables of buses, trams, or trains. A related challenge was seen in providing sufficient capacity for peak demand, given the fixed technical equipment of a potential line.

A major advantage of urban ropeways was seen in their potential to not only provide direct links for some passengers in given corridors, but to relieve congested roads and existing public transport lines. By doing so, more passengers and other road users as well could benefit from an urban ropeway. However, a general concern related to the appropriateness of adding a new means of transport when there already is an established system of public transport lines using established technologies:

> *And if we now had a ropeway or a comparable means of transport moving above the surface as the third pillar of public transport, the question would be where and how I can integrate this.*
> – local administration representative (transport planning) –

Imagining potential urban ropeway passengers, experts assumed that urban ropeway lines would be a very attractive means of transport for users, not least because of being novel or even unique, and fun to ride and experience. Yet, this relates to a lack of routine with the new means

Table 1
Typical potentials and challenges of urban ropeways mentioned during the expert workshops.

Potentials	Challenges
• Corridors where topographical barriers complicate conventional public transport extensions • Improving access to areas undersupplied with public transport • Providing access to new housing or business areas • Connecting university campuses or similar major facilities with high transport demand	• Combination with 'park and ride' facilities is challenging when creating an unattractive transfer close to the final destination • Finding corridorswith sufficiently continuous demand throughout the day; demand should not be limited to rush hou • Identifying corridors where singular advantages of urban ropeways are not outdone by other advantages of conventional means of transport

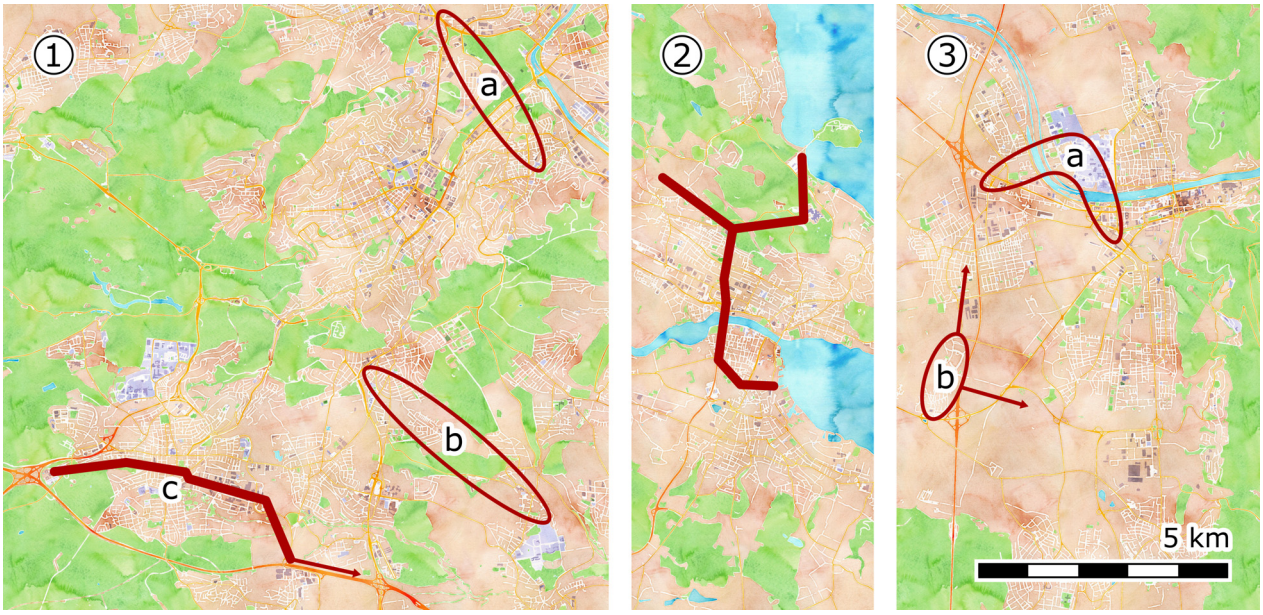

Fig. 1. Overview of potential urban ropeway corridors discussed in the expert workshops: ① Stuttgart (red: inner city basin): a) bypass to relieve city centre, b) topographically challenging link to a district without rail access, c) connecting new housing area and industrial area to public transport hub / ② Konstanz (red: Swiss-German border): potential new backbone of local public transport network, including links to university campus and new housing area / ③ Heidelberg: a) improved access to university campus, b) connecting a redevelopment area (former military housing) to existing public transport [map tiles by Stamen Design under CC BY 3.0, data by OpenStreetMap under CC BY SA].

of transport and the effect could therefore decrease over time. Generally, urban ropeways were seen as something for any kind of public transport user – only depending on whether the route fits with the respective trip requirements. Actually, this diversity was even seen as a requirement in order to justify a line that else would for example only be used by commuters during rush hours:

In urban areas I need to ensure that different users can actually use the system, out of different motivations.
– local administration representative (transport planning) –

In order to ensure attractiveness and convenience for ropeway users, a number of factors come into play that are quite similar to those of other means of public transport – and which are therefore already considered in established planning routines. Urban ropeways could offer comfortable trips and attractive travel times as well as waiting times in particular because of the continuous operation. However, it should be ensured that ticket prices are not higher than for other public transport users in the city, taking bicycles on board should similarly be possible etc., and a high availability also during adverse weather becomes a key requirement compared to tourist-oriented ropeways. Concerns related to social security when there is no staff present in each cabin, which could require specific operational measures, as well as people fearing heights. The biggest challenges were seen in the connected topics of access times, accessibility and distance between stops. Since urban ropeway stations cannot be as close as for busses or tramways, efficient interchanging points need to be designed and access and egress times should not foil otherwise attractive journey times. Ensuring accessibility, especially for persons with reduced mobility, requires considerable technical equipment at the stations, for examplelifts where those must be placed above street level, as well as slowing down or stopping the cabins to allow wheelchair access etc. This was not seen as a technical problem but rather as an area requiring significant consideration and effort during planning and operation.

Combined with the introduction of any urban ropeway line, experts saw a necessity to also think about the consequences for other means of public transport and other modes of transport. In public transport, if for example an urban ropeway aims at relieving overcrowded busses, its introduction may well imply the reduction of existing services. This will negatively affect some users and require new transfers for others. Yet, reductions that are part of a stringent reorganisation of the public transport network accompanying a new urban ropeway line were seen as a necessity in justifying that line, for example regarding financial viability. Regarding other modes of transport, particularly restrictions for private motor traffic (e.g. through closing roads or reducing parking lots) were discussed:

The ropeway only helps if I can lock out the cars as well.
– local administration representative (transport planning) –

Being aware of the challenging nature of such proposals in public discourses, such measures would aim at reclaiming urban space to improve urban quality of life, and at providing additional incentives for the actual use of the line.

3.3. Urban ropeways as a driver of urban development

Considering the perceived general attractiveness of riding and experiencing urban ropeways (see above), experts could imagine those to additionally become tourist attractions in their own right and contribute to the attractiveness of the respective city as a tourist destination. This could also provoke thinking about using private investors for building and/or operation (or letting them contribute). However, such private involvement would not fit with the requirement of orienting the urban ropeway towards efficient integration into the day-to-day public transport network, according to the experts. Still, residents would benefit from a generally improved quality of life, induced by calming crowded streets through the new transport option.

Currently, with no German city already using an urban ropeway as part of its public transport network, one considerable aspect was seen in pioneering. Being a first mover regarding the new means of transport could underpin the respective city's political support for and commitment to sustainable transport, contributing to the city's reputation:

I'd be glad if we […] were the first to do something like this.
– local administration representative (mayor's office) –

In any case, the actual planning and/or implementation of an urban ropeway was expected to lead to intense discussion among citizens as well as in the local political arena. These may particularly be triggered by impacts of an urban ropeway line like disturbances of residents' privacy along the line, noise emissions, potentially reduced property values, as well as impacts on nature reserves and wildlife. The most challenging topic, however, was seen in an urban ropeway's impact on urban landscapes. Experts could not easily imagine what this impact would actually be like and how the ropeway installations would look in detail, hence questioning how a reasonable balance with the technical requirements could be achieved, particularly in historical parts of city centres and accounting for monument conservation:

One has to ask the question about the impairment, which will not be insignificant. And then there will be a balancing decision.
– local administration representative (monument conservation) –

While finding a reasonable balance is a standard task in monument conservation, an urban ropeway with its visual impact 'in the sky' (above the city silhouette) was seen as a non-standard case to assess. The height of the ropeway installations as well as stations were also perceived to be critical issues, which can only partly be moderated by pleasant design. The novelty and lack of experience with urban ropeways as well as the subjectivity of assessing visual impacts contribute to the challenging nature of this topic.

3.4. Planning procedures for urban ropeways

Across all workshops, experts were aware of the still special character of urban ropeway projects which was assumed to affect planning processes as well. Generally, there was a perception that an urban ropeway should not be a goal in itself; rather, thorough analyses should precede the actual decision for this means of transport, checking the technical and economic feasibility as well as its fit with the respective city's actual transport needs. If such analyses showed that an urban ropeway fits best, the planning process should generally follow the standard steps in developing a public transport project, like for example inclusion in a transport development plan, technical planning, and approval, as well as civic participation.

Comparing alternatives (different ropeway layouts as well as other means of transport) was seen as a very important step of this planning process. Considering the resource-consuming planning process as well as the potential impact on the city's transport system, the responsible actors should take their time in identifying the best solution:

I think that is the important thing: that we are now basing ourselves on criteria that enable us to decide what is the right way forward. What is economic, what makes sense in terms of transport, what is socio-economically viable? These are the issues we need to work on now.
– regional transport planning representative –

Analyses were seen to be required regarding various characteristics of any urban ropeway project: What is the transport capacity (per unit of time)? How can it deal with peak demand? Which route layouts with which stations are possible? Is there enough physical space available for the required installations? What are the journey times? What will be the investment cost of the actual ropeway installation and what will be the economic performance during operaion? How is the availability regarding maintenance works as well as adverse weather? What about fire prevention and emergency response plans? Who will operate the ropeway? Will it be accepted by users – and by citizens in general? And how will it look like? These are all examples where local experts saw a new need for external support with ropeway-specific expertise – which for them has not been relevant in their day-to-day work until now, leaving them with a multitude of individual knowledge gaps. To some extent, however, also the general readiness of established planning routines with regard to consistently including urban ropeways was questioned (e.g. in demand modelling or cost-benefit analysis), since these instruments regularly refer to reference values gained from extensive experience with established means of public transport.

Despite the many open questions and the expected challenges when it comes to routine procedures in public transport planning, however, workshop participants appreciated two major promises of urban ropeways: reduced investment costs, compared with rail-based means of transport, and the possibility that regarding the actual technical planning and construction process urban ropeways could be realized much faster. For that matter, experts unanimously welcomed that the federal state government of Baden-Wurttemberg had adapted its regulation in order to provide financial sponsorship for urban ropeways similar to tramways.

Urban ropeways were seen to be not only new for transport planners, but for potential passengers and citizens as well. Combined with the generally increasing relevance of civic participation (including calls for such by political actors), this requires intense engagement with citizen interests from the outset of any potential project:

This is of course a spectacular project, because it is entirely groundbreaking. And that is why the public will probably care about it significantly more. And we will all be dealing with a subject where no one has any experience.
– local administration representative (transport planning) –

Known issues like whom to involve and how to address also those who would potentially benefit from the new transport option add to this challenge. Considering the additional lack of experience with how urban ropeways work and look like, experts saw a need to explicitly address this in the planning process and to potentially bring in additional external support.

3.5. Openness vs. uncertainties

As a recurrent theme, bringing together the various topics presented above, *uncertainty* can be identified in as a major workshop result. We therefore want to put a particular focus on this uncertainty and its elements.

A first considerable aspect of uncertainty relates to all kinds of minor and major knowledge gaps and open questions with regard to the technical characteristics and possibilities of urban ropeways as well as their visual impact on urban landscapes, regulative aspects, investment costs etc. Correspondingly, this applies to all kinds of involved actors, ranging from those involved in actual public transport operation to a bit more

distant administrative representatives who need to be involved during specific planning stages:

I do have a real knowledge deficit for some topics, where I don't know what it's like at all.
– local public transport operator representative –

You're pretty much fishing in murky waters. I feel a great uncertainty for my part, I can't judge it correctly. I'm still putting a big question mark behind it, but I think it's good that the city is working on it in a well-founded and open-ended way.
– local administration representative (monument conservation) –

However, workshop participants have taken the filling of these knowledge gaps as their task, and the open questions generally relate to issues that can be addressed by additional studies, consulting ropeway experts etc., and participants could actually see progress:

My learning curve then went steeply upwards.
–regional public transport association representative –

Therefore, in accepting the challenge (as opposed e.g. to denying the viability or general suitability of urban ropeways), urban ropeways can be read as generally accepted by the public transport service regime, i.e. regarding its perception as a serious transport alternative. This alone is a noteworthy difference to earlier years of the diffusion process when a general scepticism regarding the suitability of the technology for urban public transport prevailed.

However, specific knowledge gaps of the mentioned kinds are a typical issue in diffusion processes, and as such they are neither a fundamental problem (since they may easily be overcome through expert advice and increasing experience) nor a specific challenge for urban ropeways (since other innovations confront local planners with similar knowledge gaps). In a second, more serious perspective, though, uncertainties voiced during the workshops relate to the capability of established planning procedures to handle urban ropeway projects in the first place. The unavailability of empirically validated reference values complicates certain planning procedures, reduces their reliability, or even inhibits their application:

I believe that even an expert today cannot really assess the effects of such a ropeway for urban purposes, because nothing has really been realized anywhere yet.
– regional public transport association representative –

Moreover, experts argue that certain established planning procedures systematically cannot deal with the characteristics of urban ropeways such as their continuous operation, thereby inhibiting sound comparisons which would in turn be an important factor in arguing for an urban ropeway. Experts saw that for urban ropeways some aspects may become arguments in favour or against a certain line which are currently not reflected in planning routines at all. As a consequence, a certain degree of misalignment of urban ropeways with the existing public transport service regime remains. Still, this is not necessarily specific for urban ropeways. Rather, core regime actors themselves have identified some of the respective planning procedures as generally problematic and not fit for innovation, calling for an adapted regulation (VDV, 2018). It is thus the specific context of the dense regulatory framework in the German public transport service regime which lets this general challenge become a major barrier for the take-up of new and/or innovative solutions.

Yet, this does not imply that the complex regulatory frameworks and standardized approaches are useless obstacles that should just be eliminated. Experts acknowledged that these follow important rationales, particularly in providing procedures that ensure meeting the goals of an integrated public transport system and the efficient use of public money. Rather, the challenges identified show that the current planning system is not well prepared to use technological progress and service innovations in the pace that service regime actors themselves see as becoming a necessity.

At this point, the relations of service regime actors with actors both in the sectoral regime (particularly regulators) and in the socio-technical landscape (particularly political actors at the local level) come into play. On the one hand, with something innovative like an urban ropeway, the planning process may uncover regulatory need for action (see above). On the other hand, political actors may actually trigger debates about introducing the new means of transport and political decisions – as well as citizen sentiments and public discourse may critically influence the course of such a project. Experts also voiced an expectation that an urban ropeway project could play an important role as a milestone for urban development. But despite that, most experts did not see too much emotion in their work, focussing instead on their respective tasks to provide a sound basis for decision-making and accepting that the actual decision will ultimately be in the hands of political actors:

It's actually still passionless for me. I am in favour of a means of transport with which we can handle our traffic, because that is where I see my responsibility.
– local administration representative (building department) –

Though, a general openness towards considering urban ropeways as a serious option was voiced several times during the workshops.[2] This openness must be read as an important factor in allowing the required realignment processes also through action from within the established public transport regime:

I believe that this is a very important issue: openness to innovation, openness to different patterns of mobility among different people and not being strictly in one's own line.
– local public transport operator representative –

This comes in addition to the developments at the niche and socio-technical landscape levels (cf. Reichenbach & Puhe, 2018). In turn, experts sometimes wish they received more political support also when they are actually implementing measures and projects, in a state of projects when they also experience opposition from affected residents etc. However, the representatives of the public transport service regime involved in the workshops have accepted the challenging realignment process.

4. Discussion

Our results highlight different kinds of knowledge deficits and uncertainties as crucial barriers opposing the planning and implementation of urban ropeways. Considering our analytical lens, we can differentiate these issues by their relevance for the general diffusion process of urban ropeways, ranging from simple, case-specific questions to systematic challenges at the level of the service regime (Fig. 2).

First, we have documented a general appreciation of the technological potentials of urban ropeways by local public transport actors, whether or not that option may fit with the requirements of their specific issues in their local transport systems. There may thus be open questions, but no general misalignment can be observed. When it comes to imagining detailed planning steps of any potential project, individual actors' knowledge gaps become more manifest and increase the efforts needed to overcome them, particularly when compared to established means of public transport. For example, additional external expertise may be required that needs to be paid for (e.g. commissioning reports). The same holds true for balancing out transport needs with, for example, urban development and monument conservation. Similarly, and bring-

[2] The discussion dynamics during the workshops may have contributed to this consistent tune. However, the open atmosphere (incl. space for controversial views) and participants' repeated references to earlier skeptical reactions give us confidence in trusting our observation.

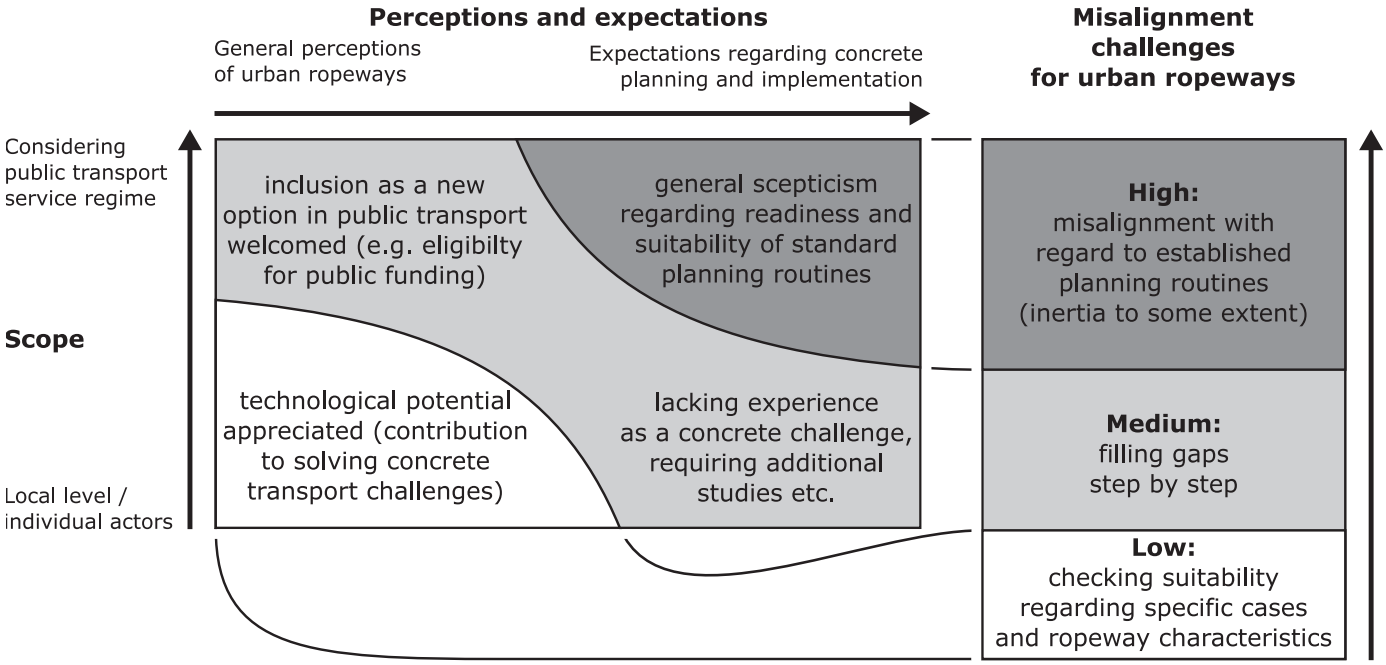

Fig. 2. Misalignment challenges for urban ropeways (own figure).

ing the wider service regime framework into consideration, some legislation etc. has already been updated to cover urban ropeways, but some gaps remain and urban ropeways are not yet covered at the same level of detail (e.g. adding or altering assessment criteria). However, barriers become more fundamental when envisioning concrete planning procedures: While filling knowledge gaps during a diffusion process is a typical step, the dense regulatory framework, since it is partly built around existing reference values (particularly in project appraisal), complicates entering that learning process in the first place, when knowledge deficits still exist. Only through the specific arrangements in the service regime, this mechanism gets its chicken-and-egg problem nature. This is where misalignment between urban ropeways and the public transport service regime is most clearly visible. Moreover, those setting and developing further the regulatory framework (thereby potentially reducing misalignment and inertia more generally) do not coincide with those confronted with inertia in their local planning practice. From a local perspective and considering again the identified general openness, this further adds to the issue, since local actors – apparently bound to available planning tools – do not see themselves in a position to challenge the general framework.

Recent developments beyond the expert workshops and our study indicate that the service regime itself also acknowledges the identified challenges, as also indicated in the introduction. Most prominently, a federal law guiding financial support for transport investments has been changed (as a result from the parliamentary process) to include urban ropeways as a public transport option. The Federal Ministry of Transport and Digital Infrastructure invited a working group on urban ropeways that is also continued under the 2021 government, and urban ropeway characteristics are expected to be considered in an ongoing revision of the standard cost-benefit analysis tool. Two publicly funded projects currently work towards providing specific guidelines and planning tools for urban ropeways. At the level of the federal states, actors are considering guidelines or provide specific financial support for cities requiring additional expertise. These developments provide concrete examples for an active step-by-step closing of existing gaps, which reduces misalignment. Altogether, this further illustrates the current realignment process working towards an integration of ropeways into the standard repertoire of public transport planning and provision. At the city level, the ongoing studies in Konstanz and Stuttgart fit our observations, as well as broad media coverage and recent urban ropeway projects from a number of other German cities (e.g. Bonn, Munich, or the Frankfurt region). Adding to our research results presented above, this underlines the re-orientation of service regime actors towards the potentials (and challenges) of new and innovative solutions where established public transport solutions do no more suffice to solve transport challenges.

Yet, these initiatives challenge the structural factors of inertia built into the general framework just as little, at least not systematically. At the same time, it becomes obvious that the sector needs to bring itself in a position where it becomes easier – or possible at all – to learn and use innovative approaches (incl. specific technologies) that reach out beyond conventional categories. It remains questionable whether this can be done by adding new instruments (e.g. regulatory sandboxes or the various kinds of experimentation, cf. McCrory et al., 2020), or whether putting into question the general assumptions and approaches of the regulatory framework will also be necessary (cf. Lyons & Davidson, 2016).

5. Conclusion

Our findings add an important lens to understanding the potential of urban ropeways to contribute to a mobility transition and more sustainable urban mobility. The technical characteristics and limitations clearly rule out urban ropeways as a silver bullet to transport problems, limiting those to cases where they can show their specific advantages compared with established modes. Our study complements this technological view with a perspective on specific challenges in planning and implementing urban ropeways in the context of the practices and routines of typical public transport service regime actors.

In a wider sense, our case study of urban ropeways also serves to illustrate the structural conditions for innovation in the public transport service regime more generally. We have used the rather clearly defined case of urban ropeways to learn about structural barriers and factors of inertia in Germany that oppose the diffusion process of the technology, how actors engage with alternatives and organise realignment, and how remaining aspects of misalignment are dealt with. Other technological developments, for example considering the still much fuzzier fields of ride-sharing, ride-pooling, or autonomous shuttles, are currently affect-

ing and will further affect how the transport system is organised. These technologies are assumed to have a considerable potential of changing the sectoral regime as a whole, including a new balance between transport modes, user expectations, patterns of use, extensive need for regulation etc. For example, new routines for public transport network planning or public tendering may be needed, or new criteria for cost-benefit analyses may need to be developed, similar to urban ropeways, but possibly with an even more fundamental need for new methodological approaches. In many cases, the new technologies will also imply a growing multitude of involved actors, particularly considering stronger links with information and communication technology providers. These developments pose significant challenges to the public transport service regime and its future relevance. However, the different material natures of the various technological developments should also be considered. The testing of new sharing or shuttle services, for example, does not require built infrastructure to an extent comparable to urban ropeways. As a consequence, such differences also affect the ways in which technologies can be tested and how institional learning may take place.

Altogether, the results of our study further underpin our perspective that the future of public transport is not just a technology issue. Public transport plays an important role in ensuring climate-friendly mobility and reducing negative effects of the current mobility system. It is crucial to improve our understanding of how socio-technical reconfiguration processes in the public transport service regime take place, how it keeps pace with technological progress, and which role practices and routines as well as structural factors of inertia play in these processes. Combined with rising political and public awareness (and rising funding opportunities for cities), this perspective may provide additional scientific support for a mobility transition, particularly considering the challenges for ambitious actors at the local level who are confronted with the practical effects of structural barriers. The insights gained from our study aim at enriching that knowledge base by a small piece of the puzzle. They also provide a number of links for future research, namely regarding the transferability of our findings to the more complex reconfiguration processes to be expected as a consequence of the more far-reaching technological developments identified above.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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